**EMPIRICAL APPROACH TO GROWTH ANALYSIS – PECULARITIES FOR MODELING STRATEGY IN THE CASES OF BIG EXOGENIOUS SHOCKS**

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**Abstract**

*Empirical investigation on growth, especially in the course of big exogenous shocks is still relatively ambiguous. While models of developed economies describe the growth process as a smooth movement along the balanced growth path, this pattern is altered in the cases of big exogenous shocks that hit economies. The later accumulation of evidence, including the big shocks due to pandemic and Russia - Ukraine war led to more realistic specifications of growth models as well, putting the emphasize on the impact of shocks on growth processes. Hence, the main objective of this paper is to provide a review of the papers that investigate empirically growth and its main determinants, with the accent on analysis of the impact of shocks on growth patterns. A distinction is made between studies that investigate developed economies and those that concentrate on developing or transition economies. The former ones usually apply the modelling strategy based on the neoclassical linear framework and, their review offers valuable insight and overview of the variables mostly used in growth studies. On the other side, the studies concerning developing or transition countries are rather focused on finding new ways of empirically modelling growth in specific conditions of shocks. Although still the majority of the analyses are based on the linearity assumption, in this review we shall treat only the ones that introduce non-linearity in the growth studies, assessing the ways they address the non-linearity observed in the data generating processes. Finally, the proposed strategy for modelling big shocks in the growth pattern is adjusted growth accounting formula with Markov Switching Vector Autoregressive modelling. The modest number of variables is due to the intention of the empirical exercise to put a focus on the shifts in growth rather than on the detailed determinants behind the shifts. Additionally, it should be emphasized that the informative purpose of this empirical model is limited by the lack of data for other possible variables and by the modelling procedure.*

**Key words:** Economic growth, Shocks, Modelling strategy, Transition Countries.

**Introduction**

In general, growth theory does not offer a clear-cut path towards empirical investigation on growth, especially in the course of big exogenous shocks. Temple (1999) noticed that the empirical work on growth has often been controversial due to the widespread feeling that growth theory and econometrics are best kept apart. In fact, the lack of an apparent theoretical background has led empirical economists to follow theory loosely and simply "try" various variables as potentially important determinants of growth (Sala-i-Martin, 1997, Fischer and Gelb, 1991, Temple 1999). In consequence, the number of growth regression has grown far faster than the economies they analyse (Hendry and Krolzig, 2004). Many of these novel and informal models were initially described as mongrel or ad hoc regressions. Yet, they have gradually become the principal mode of analysing growth in general (Fischer, 1993).

The main goal of this paper is to provide a review of the papers that investigate empirically growth and its main determinants, with the accent on analysis of the impact of shocks on growth patterns. A distinction is made between studies that investigate developed economies and those that concentrate on developing and transition economies. The reason for this is that they are different with respect to the modelling approach, yet share the same neoclassical origins in terms of selection of the variables. The former ones usually apply the modelling strategy based on the neoclassical linear framework and, their review offers valuable insight and overview of the variables mostly used in growth studies. On the other side, the studies concerning developing countries are rather focused on finding new ways of empirically modelling growth in specific conditions of shocks. Although still the majority of the analyses are based on the linearity assumption, in this review we shall treat only the ones that introduce non-linearity in the growth studies, assessing the ways they address the non-linearity observed in the data generating processes.

The aspiration to address the above questions shaped this paper. Hence, it is organized as follows. Second section gives the main theoretical background, followed by the review of papers that apply this approach in this research. Section 3 is setting out the main characteristics of the models in the case of transition or developing countries, followed by the discussion of the problem of endogeneity in growth regressions. Section 5 presents the adjusted growth accounting formula with MSVAR that could be applied for capturing big shocks. The last section concludes.

1. **Theoretical background on modelling growth and its determinants**

**through modified growth accounting framework**

The augmented-Solow model is the starting point in the review of the empirical findings on growth. Mankiw et al. (1992) examined whether the original Solow growth model can explain the international variations in the standard of living. The first tested model regressed the real GDP per worker for each year on two main variables: n - average rate of growth of the working-age population between 15 and 64 years and s - the average share of real investment (including government investment) in real CDP. The data used in the study are from the Real National Accounts constructed by Robert Summers and Alan Heston from 1988.

Using the model, the data on three samples of countries (98, 75 and 22 OECD countries and OLS techniques they found that the model correctly predicts the direction of the effects of the different factors, such as saving (*s*) and population growth (*n*), but it overstates their magnitudes. The saving variable actually is the fraction of income invested in physical capital, which indirectly in the equation measures the share of change of capital. The value of implied by the coefficients should equal capital’s share in income, which according to Mankiw et al. (1992) is roughly 1/3. However, the estimates without human capital imply a much higher value (0.59) with a standard error of 0.02.

Because the estimates implied a high capital share, Mankiw et al. (1992) augmented the Solow model by including accumulation of *human capital* as an explanatory variable in their cross-country regressions. The improved model regresses ln(GDP per worker) on ln(capital per worker) and ln(human capital per worker), while the estimate for capital per worker is the investment rate in physical capital over 1960-1985 and the estimate for human capital is the investment rate in human capital over 1960-85 measured as a percentage of secondary-school students in the working-age population.

Inclusion of human capital altered the empirical modelling, but also the theoretical modelling of economic growth. At the theoretical level, the inclusion of human capital altered the notion of diminishing returns to reproduceable capital, which became constant returns to broad capital (Lucas, 1988). However, Mankiw et al. (1992) preserved the notion of diminishing returns to all capital in their modelling, assuming that . In this case, the economy will converge to its steady state as explained in Solow. After imputing the human capital variable and regressing, Mankiw et al. (1992) found out that the human capital accumulation measure enters significantly in all three samples. In addition, their augmented model explains 80 per cent of the cross-country variation in income per capita from three variables: population growth; and investment rates in physical and human capital. The high *R2* is the basis of Mankiw's (1995) conclusion that: "Put simply, most international differences in living standards can be explained by differences in accumulation of both human and physical capital” (p. 295). The corollary of their finding is that differences in technical efficiency, which on the other hand depend on resource endowments, climate, education, institutions and so on, and differ across countries, can have a relatively small role (less than 20 per cent) to play in explaining cross-country income variations.

Subsequently, Klenow and Rodriguez-Clare (1997) have drawn attention to the relatively exaggerated estimation of human capital in the Mankiw et al. model arguing that an important issue is how exactly human capital is measured in the models as sometimes human capital estimates can absorb part of the TFP specific for the countries. Klenow and Rodriguez-Clare (1997) offer more exact measures of human capital for 98 countries, by updating Mankiw et al.’s data and adding data on primary and tertiary schooling in the model, as well as taking into account worker experience and the quality of education. Additionally, they offer extensive explanation and estimation of experience and quality of education for the countries in their analysis. The main finding is not surprising; namely, that richer countries have older workforces and higher quality of education which, combined with the physical capital, results in higher growth rates. In addition, they argue that the Mankiw et al. (1992) estimates of human capital effects do not capture only private gains but also the social gains of schooling that are always larger than the private benefit, consequently amplifying the role of human capital in the regressions. Correcting for this and using the same estimates for physical capital, they find that total factor productivity differences account for half or more of level differences in 1985 GDP per worker levels. In addition, when testing the growth rates (instead of levels) for the four Asian tigers (Hong Kong; Singapore; South Korea and Taiwan from the study of Young, 1995) they find that roughly 90% of country differences in *Y/L* growth are attributable to differences in *A* growth. Combining these growth results with their findings on levels, they call for returning productivity differences to the centre of theorizing about international differences in output per worker.

Although with various findings with respect to the size of the contribution of human capital to growth, growth empirics in general did emphasize the importance of the exact measure of human capital that enters the growth regression. This seems especially important for the case of developed economies where human capital plays a significant role in growth through the engagement in research and development.

Bassanini and Scarpetta (2001) also have tested the augmented Solow model in the case of 21 OECD countries over a period 1971-1998. They started with a simple specification of the growth equation and then analysed extended models. Their initial specification is consistent with the neoclassical growth model including the convergence factor and the basic determinants such as accumulation of physical capital and population growth, similar to the one used in our model. The first extension involves human capital and further considers R&D, and a set of policy and institutional factors potentially affecting economic efficiency. Considering pooled cross-country time series (*i* denotes countries and *t* time) they have written the model in general form:

 Equation 1

where y is GDP per capita, *sk* is the propensity to accumulate physical capital, *h* is human capital, n is population growth, the VI is the vector of variables affecting economic efficiency, t is a time trend, the b- regressors capture short-term dynamics and  is the usual error term.

As the equation suggest, the most interesting novel aspect in this study is the differentiation between the long-run and the short-run dynamics in the model by including first differences of the steady-state determinants as short-run regressors in the estimated equations (Bassanini and Scarpetta, 2001). Under the assumption of long-run slope homogeneity, they use the pooled mean group estimator that allows intercepts, the convergence parameter (), short-run coefficients and error variances to differ freely across countries, but imposes homogeneity on long-run coefficients. The homogeneity of the long-run coefficients actually implies that the countries will approach the same steady state growth rate in the long run, which is due to similarity of the countries in terms of common technologies and intensive intra-trade and FDI and also due to the constancy of the coefficients across time.

Nonetheless, the introduction of the short-run dynamic and the allowance for it to differ across countries clearly implies that even in the case of developed and very similar countries the movement towards the steady state is not always smooth and linear; and neither is it equal for all the countries at a certain point of time.

1. **Empirical studies of growth in the case of big shocks**

Since growth processes in developing and transition countries may be very different to those countries near the technological frontiers, one should often be careful about extrapolating findings from the developing countries to the more developed and vice versa (Temple, 1999). As shown in the previous section, while explaining growth differences among developed countries most studies use balanced growth models, which means that several aggregate "great ratios" evolve smoothly over time, following the transitional path given in the neoclassical model. However, Pritchett (1997) notices that the history of many developing and transition countries has been marked by alternating booms and growth collapses that are rarely studied in the growth studies of transition. Instead, most empirical studies of transition still employ balanced growth models, following the example of growth studies of developed countries, generally disregarding the dramatic shifts of growth experienced by developing and transition countries, or alternatively only including them as variables in the otherwise linear system (Jones and Olken, 2005). In many cases, although the output fluctuations can be easily perceived by looking at the time series behaviour of growth rates within countries, mainly in recent times, several influential authors as Pritchett (2000), Easterly et al. (1993, 2000) and Easterly (2009c) stressed the serious shortcoming of the standard empirical approach to growth. They claimed that a general framework is needed for thinking about macroeconomic discontinuities – one that encompasses differences among countries.

Jones and Olken (2005) explored a less common approach to growth that emphasizes actually the variation of the growth experience *within* countries. They examined more deeply the changes that occur when growth starts and stops in one country. Claiming that the transition between different growth regimes is highly important for better understanding of growth in all countries (except for richest ones), firstly, they identify structural breaks in the growth series for individual countries using the methodology of Bai and Perron (2003) and data from the Penn World Tables (Heston et al. 2012). Then, they use the accounting exercise to analyse whether observable factors, such as the accumulation of physical capital, human capital, or changes in factor intensity, can account for significant parts of the structural change, or whether TFP, the unobserved residual, is left to explain the growth breaks. The growth rate in the physical capital stock per-capita is defined as

  Equation 2

where *I* is gross investment, and *n*, the population growth rate and the depreciation rate, *δ*, is assumed to be 7%; while for measuring the human capital they start with taking the standard assumption of Mincerian returns to schooling which implies a 10% return in wages to an additional year of schooling, hence if s is years of schooling the growth rate of human capital can be calculated as:

  Equation 3

The analysis suggests that changes in the rate of factor accumulation explain relatively little of the growth reversals, especially for accelerations. Instead, the growth reversals are largely due to shifts in the growth rate of productivity. They find very similar results by using independent data on electricity consumption to infer total capital utilization rather than relying on investment data from the national accounts. The electricity data only confirms the previous findings, suggesting an efficiency story.

Young (1995, 2000) has emphasized another problem related to the growth analysis in the developing countries and that is the problem of misstating the data in the national statistics in the socialist country of China. He analysed the economic performance of the Republic of China using the statistics given by the national statistical office of China but making systematic adjustments using their own data. By simple descriptive but rather profound analysis on each data sets on labour market movements, he showed that the growth rates during the reform period in China 1978-98 are close to ones previously experienced by other rapidly growing economies. Namely, he claimed that the key force explaining the extraordinary improvements in per capita living standards in China is the labour deepening (the rise in participation rates, transfer of labour out of agriculture, and improvements in educational attainment) and *not* capital deepening. After taking into account these labour changes, he found that labour and total factor productivity growth in the non-agricultural economy are found to be 2.6 and 1.4 per cent per year, respectively; a respectable performance, but by no means extraordinary.

1. **Growth regression exercises in developing or transition countries**

In the case of developing and transition countries, growth empirics are even more ambiguous owing to the complexity of economic growth, the short span of data and the absence of coherent theory that explains and encompasses all processes. However, even in the limited cases that empirically analyse big shocks, the analysis is mainly based on the balanced linear growth model which, in turn, as mentioned before, disregards the huge changes experienced in the course of shocks (De Melo et al, 1996 and 2001; Fidrmuc, 2003; Havrylyshyn and Rooden, 2000; Fischer and Sahay, 2000).

In general, alongside with the short length of data necessary for growth analysis, the main problem is that growth literature, which makes heavy use of balanced growth models, generally disregards the dramatic changes experienced by all developing and transition economies, whether these are described as structural changes, factors’ reallocations, institutional changes and so on (Kongsamut et al. 2001). In fact in empirical work, these changes are included as a separate variables in the growth regression models, but still within the linear framework, not allowing for their more substantial impact in the estimation procedure.

In general, the main model, which is used in studies, has the following linear equation form:

  Equation 4

where *y* is the GDP per capita growth rate, *Z* is a vector of core variables that usually appear in growth regressions such as initial level of GDP per capita, the investment rate, the secondary school enrolment rate and the rate of population growth, *X* is a vector of variables of interest and *u* is the error term. The choice of the included variables is based on past empirical studies and economic theory, while usually panel modelling is used in order to overcome the problem of lack of data and to obtain results, which will be relevant for the whole or separate groups of the world (Hamma et al., 2012).

1. **Endogeneity in the regression analysis of growth**

One important problem already recognized in the growth empirical literature is the potential endogeneity of the variables used in the growth regressions stemming from the interrelation of the determinants within the growth system (Pritchett, 2000).

Broadly, endogeneity is a situation when one or more independent variable(s) is correlated with the error term in the regression model, which gives rise to biased regression coefficients[[2]](#footnote-2) (Wooldridge, 2002). In brief, there are several reasons for endogeneity, such as omitted variables, measurement problem and simultaneity, which may be particularly pronounced in dynamic systems.

* In the omitted variables case, there is a variable (or more than one variable) that needs to be included in the analysis based on the theoretical and empirical grounds and is correlated with the included variables, but still, it is not represented in the empirical model due to lack of data or insufficient knowledge.
* In the measurement error case, the estimation of the effect of certain explanatory variables on *y* is ambiguous if one or more variables are mismeasured.
* In the case of simultaneity, one or more of the explanatory variables and the dependent variable mutually determine one another (Wooldridge, 2000).

In the former two cases, the problems can be solved if better data are collected, while the latter case requires specific modelling approaches that will enable estimating unbiased regression coefficients (Wooldridge, 2002).

However, the last important source of endogeneity relevant for the dynamic systems econometric modelling, in particular, is simultaneity. Simultaneity arises when one or more of the explanatory variables and the dependent variable mutually determine one another (Wooldridge, 2000). In fact, simultaneity is the situation when the one-way causal relationship between the independent and dependent variable is accompanied by a backward causal relationship i.e. the dependent variable affects the independent variable, creating a two-way causal connection(s) among the dependent and independent variable(s) in the model. This situation is particularly relevant in the context of time series analysis of causal processes. Simultaneity occurs in dynamic models and systems where the variables, dependant and independent, are interconnected.

The possibility of mutual causation between determinants of growth and the growth of GDP has been already recognized in the growth literature (Mirestean and Tsangarides, 2009, Durlauf et al., 2008). Many authors have stressed that alongside the main relation – from the growth determinants - physical and human capital- to GDP growth, there is also a backward relation; that is:

* GDP growth is a determinant of the flow of investments and hence the physical capital flow (Jorgenson, 1963, Lucas and Prescott, 1971, Hall and Jorgenson, 1971, De Long and Summers, 1991); and,
* GDP growth is a determinant of employment and human capital development (Lucas, 1988, Barro and Lee, 2000).

Conventional economic thought has already established the relation between the growth of the economy and the *physical capital changes* in the concept of the accelerator effect. According to this conception, businesses will be encouraged to make new investments increasing the physical capital stock, determined by - among other factors - the expected profit rate; which in turn depends on the growth of the economy (Jorgenson, 1963). Broadly, rising GDP (in an economic boom or prosperity) implies that businesses expect increasing sales, cash flow, more efficient use of the capacity and rising profits, which would encourage further investment in physical capital such as equipment and improved technology (Hall and Jorgenson, 1967). The opposite happens in the case of falling GDP when businesses are reluctant to invest as they expect falling sales and a worsened economic environment. As business confidence falls, the discouraged businesses may lead to negative growth of the economy through the further decrease of consumer incomes and purchases resulting in negative multiplier effects (Lucas and Prescott, 1971). Although mainly related to business cycle movements and the business cycle concept, the feedback relationship between GDP growth and physical capital growth has general economic relevance, because it is part of the reasons behind deeper recessions and growth failure (Hall, 1993, Kornai, 1994). Namely, Hall (1993) found that the falling investment played a part in deepening recession. Explaining the vicious circle that developed in the course of the recession in United States in 1990-91, Hall (1993, p.5) concluded:

*Firms cut all forms of investment; again, as they would if there had been some permanent adverse shock. As usual in a recession, firms cut production by more than their sales fell, making up the difference from inventories.*

The economic literature also documents the two-way relationship between GDP growth and changes in the labour market (employment growth and human capital development). Namely, economic growth is not only determined by the labour and human capital among other factors, as discussed by the endogenous growth theories (Lucas, 1988, Barro and Lee, 2000); but also economic growth causes changes in the employment and human capital in an economy (Hull, 2009, Satchi and Temple, 2006). Although it is not always clear how economic growth translates into labour market outcomes, in general, the literature suggests that positive economic growth exerts two main effects on labour markets: firstly, it stimulates job creation or employment increase (changes in the quantity of labour); and, moreover, it stimulates human capital development (changes in the quality of labour)[[3]](#footnote-3). The first effect is usually measured by the employment intensity of economic growth that is the growth in employment resulting from the growth in output (Hull, 2009). High employment intensity indicates that growth in output leads to considerable job creation, while low estimates of employment intensity suggest little correlation between economic growth and employment. The latter case is usually referred to as a “jobless recovery”, which can happen due to a variety of situations (Glosser and Golden, 2005). Namely, in some cases, economic growth favours increase in labour utilization rather than increase the number of jobs. This is especially emphasized in the eve of recessions, when companies are more reluctant to hire new workers until they are convinced about the sustainability of a new economic recovery (Glosser and Golden, 2005). Finally, another possibility is that companies employ new technologies and high-skilled labour resulting in increased productivity instead of mass job creation. In the latter case, the effects are related to improving the labour quality that is human capital development instead of increase in employment (Hull, 2009). In the opposite case of negative economic growth, the relation between the economic decline and labour market outcomes is again confirmed; with prompt or lagged conversion of economic downturn into increase in unemployment and negative impact on human development (Maddison, 1987).

Although brief, the above discussions suggest that economic growth measured by the GDP growth affects the two main determinants of growth, thereby implying the problem of endogeneity in the empirical model. This is an important empirical problem that results in biased regression coefficients; hence, the results of the single equation regime switching regressions undertaken in the course of this research are not reported. Instead, in order to address the possible mutual determination of the dependent and independent variables, the Markov Switching Vector Autoregressive (MSVAR) model can be applied in modelling of GDP growth dynamics in the course of big shocks. The MSVAR system addresses the problem of endogeneity as it allows modelling a system whereby each potentially endogenous variable is regressed on lags of all other potentially endogenous variables subject to the switch. In addition, this methodology has several other advantages: it not only allows for the inclusion of variables that are endogenous in a statistical sense, but it also encompasses the dynamic relationships among the variables and, also, the dynamic evolution of the growth process we are interested in. All of these - modelling the dynamics of growth as switching regimes and incorporating endogeneity - are issues of particular relevance to growth analyses that have been rarely considered jointly and, to our knowledge, have never been considered jointly in studies of growth in the course of big shocks. Hence, the following analysis attempts to fill this gap in the growth literature.

1. **Adjusted growth accounting formula with MSVAR**

The theoretical departures explained above, accompanied by the problems of: lack of data, suspected nonlinear nature of the growth and the inability to conduct a growth accounting exercise for developing or transition countries in the traditional fashion, urged the need for alternative ways to conduct regression analysis that would eventually yield better and feasible empirical presentation of the big structural changes in the course of economic growth.

Hence, the regression approach analogous to “growth accounting” is proposed in order to enable estimation of the contribution of the various factors to growth as identified by the Solow model, by relating growth in GDP to growth in fixed physical capital and to growth in employment. The estimable regression equation is as follows:

 ,  Equation 5

Whereby is the GDP growth rate, is fixed physical capital growth rate, is the growth in employment, *t –* is time subscript, and  are the coefficients on the variables, *ut* is the error term which has a statistical role to capture the errors not captured by the variables in the model. The constant term α0 will play the role of the technology term in the growth accounting framework - , i.e. capturing all the systematic effects that are not included in the other two variables. In fact, the constant term will act as a “Solow residual”, capturing all the systematic changes not included in the model variables. This is a very important feature enabled by use of the Markov Switching framework into the growth regression.

Conceptually, this is the regression version of the growth accounting formula. This regression relates the economic growth over the period of observation to the basic measures of physical and labour growth and to the unobserved technical change. As given in the Equation 5, the model includes two factors: labour (*L*) and physical capital (*K*). The measure of the human capital is not included simply because of the difficulties to estimate it in the developing or transition countries context. However, we believe that the changes and possible obsolescence of human capital will be captured in the intercept term in the model. The modest number of variables is due to the intention of the empirical exercise to put a focus on the shifts in growth rather than on the detailed determinants behind the shifts. Additionally, it should be emphasized that the informative purpose of this empirical model is limited by the lack of data for other possible variables and by the modelling procedure. Namely, the MSVAR modelling procedure becomes truly data consuming, especially when the switching regimes are introduced, which exponentially increases the number of the parameters to be estimated. In summary, the empirical investigation of growth and especially of growth switches is highly restricted when the range of potential factors and changes is large relative to the number of observations.

The Markov Switching models are presented in a more technical manner in three steps, starting with the explanation of the time series *yt* in the first step. Then, the second step offers a closer look into the switching property, which incorporates the characteristics of the switching hidden variable or process *st* . Lastly, the third step gives the description of the dependency between the switching hidden variable *st* and the time series *yt*. The following explanation follows closely those of Hamilton (1994), Krolzig (2000) and Frühwirth-Schnatter (2006).

**Step One.** The properties of the time series *yt*, or named as Yt conditions.

To begin with, time series data usually reflects the dynamic consequences of events over time (Hamilton, 1994). In some cases, the events might be influenced by the events in the past. In the simplest manner, in mean adjusted form, the standard model to capture the corresponding autocorrelation is the AR*(p)* model relating the value of the variable *y* at date *t* to the value that *y* took in the previous periods t-1,.., *t-p*:

 ****, **** Equation 6

where *yt* is the variable of interest, *µ* is the mean of the series, *t* indexes time (periods), *p* the number of lags and *ut* is the usual error term. For the standard AR model, the Equation 6 is completely equivalent to the model given in the following familiar Equation 7,

 ****  Equation 7

with the constant term . Since the mean is the same for the whole series in the standard AR model, the constant is capturing the effects of the autoregressive parameters multiplied by the mean.

Now, Markov Switching Models (MS) start with the assumption that *yt* switches regimes according to the unobserved variable *st,*. The *st,* variable can be considered as a hidden stochastic process that determines the distribution of another observable stochastic process *yt*. As is common in time series analysis, the *yt*  variable can be considered as the realization of a stochastic process. The *st,* variable also. Hence, the modelling is based on a doubly stochastic time series model and the dependence between the two series.

**Step Two.** The properties of the hidden process *st*, or named as St  conditions.

The variable *st,* is a latent random process that can be observable only indirectly through the impact it has on the observable stochastic process *yt.* (Frühwirth–Schnatter, 2006). Additionally, it is assumed that the unobserved variable’s movements (*st,*) between regimes are governed by an irreducible, aperiodic, ergodic Markov Chain, defined by transition probabilities between N states or regimes (Krolzig, 2000).

If all the regimes have a positive unconditional probability, the process is called irreducible (Krolzig, 1998). Irreducible means that the system can equally move from any state to any state or it can remain in the same state. Aperiodicity means that the system can return to any state at irregular times. A finite Markov Chain is ergodic if exactly one of the eigenvalues of the transition matrix is unity and all other eigenvalues are inside the unit circle (Krolzig, 1998). Under this condition there exists stationarity or an unconditional probability distribution of the regimes; i.e. transition probabilities cannot be trended.

In simple words, based on the observable data *yt,* the MS estimator determines: the number of regimes; their timing; and the probability of each possible transition of the system from one regime to another. For example, the transition from regime *i* to regime *j* when the number of states is two (N=2) is given by the equation:

 **** **** Equation 8

which means the probability of currently being in state *j* (*st =j*) conditional on having been in state *i in* the previous period (*st-1 =i)*. Hence, as can be seen from the equation, the probability distribution of the state at any time *t* depends only on the state at the time *t-1* and not on the previous states, such as *t-2, t-p*…etc.[[4]](#footnote-4) That is, the basic Markov process is not “path dependent” (Brooks, 2002).[[5]](#footnote-5)

Because the system has to be in one of the N states at a certain time t, it will follow:

 **** Equation 9

The sum of the probabilities of being in state *j*, conditional on being in previous regime *i* equals 1. For example, since the state variable is unobservable, it is necessary to form probabilistic inferences of its value, governed by a Markov chain. If two states are assumed *s=1, s=2*, i.e. *N=2* regimes, then there are four probabilistic inferences: a) the system to be in regime one and to remain in the same regime where is the probability that the system will remain in the same regime; b) the system to move from regime 1 to regime 2, i.e. where is the probability that the system will move from state 1 to state 2; c) the system to move from regime 2 to regime 1, i.e. where is the probability that the system will move from state 2 to state 1; d) the system to be in regime 2 and to remain in the same regime, i.e. where is the probability that the system will remain in state 2. These transition probabilities are restricted so that  .

**Step Three.** Finally, the last step establishes the dependence of the distribution of *yt* on *st*. In each moment in time, the distribution of *yt* depends on the state *st*, but this dependency can vary, based on the various assumptions that are fulfilled in different models.

**Conclusion**

In summary, while most of the growth models of developed countries describe the growth process as a smooth movement along the balanced growth path, this impression changes for the cases of developing and transition countries as we argued in this paper. The later accumulation of evidence about growth in countries led to more realistic specifications of growth models. However, to make the best use of the existing empirical material, we believe that it is necessary to reshape and extend earlier models so as to make them more relevant to the processes of growth in the case of big shocks.

In addition, the small and simple empirical models of growth based on the basic growth accounting equation deduced from the standard production function, comprising labour and physical capital variable and technical progress, captured by the intercept, which is considered as exogenous, can be the most appropriate solution in the case of capturing big shocks. Indeed, it is a relatively modest model that attempts to acquire information on the dynamics of growth switches rather than understanding of the myriad of potential growth determinants. Hence, we consider that the omitted variables issue is not a primary concern in the research of growth in transition or developing countries.

Finally, when the big shocks cause shifts in growth patterns, creating growth regimes the use of Markov Switching framework is proposed as it has propensity to capture the nonlinear data generating process for analysing the impact of big shocks on economic growth.

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1. University St. Kliment Ohridki – Bitola, Faculty of Economics – Prilep; email: natasha.trajkova@uklo.edu.mk [↑](#footnote-ref-1)
2. More on the explanation and sources of endogeneity see Wooldridge, 2002. [↑](#footnote-ref-2)
3. Indeed, the impact and the effects of the interrelations depend on many factors studied in the literature, such as: the level of development of the country, the type of growth, the level of urbanization of the country, the labour market characteristics such as its sectorial structure, the share of informal sector, labour income and so on (Satchi and Temple, 2006). [↑](#footnote-ref-3)
4. In order for the hidden process to be fully specified, the initial distribution of the *st* variable should be specified. As mentioned, the Basic Markov Switching Model starts with the ergodic transition matrix. However, this assumption can also be relaxed by allowing the initial distribution to be arbitrary – uniform or unknown (estimated), needed to be estimated from the data. In Ox Metrics, these options are available. [↑](#footnote-ref-4)
5. However, it should be noted that the Basic Markov Switching model has been extended with the aim of formulating even more flexible models for a wide range of time series data. These models do allow for containing the history property of the regimes condensed in the “memory” of the state variable (Mizrach and Watkins, 1999; Frühwirth – Schnatter, 2006). [↑](#footnote-ref-5)